

# Fabrication of flexible, conductive polypyrrole-graphene quantum dot (PPy-GQD) nanocomposite via electrodeposition on carbon fiber mesh



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## Abstract

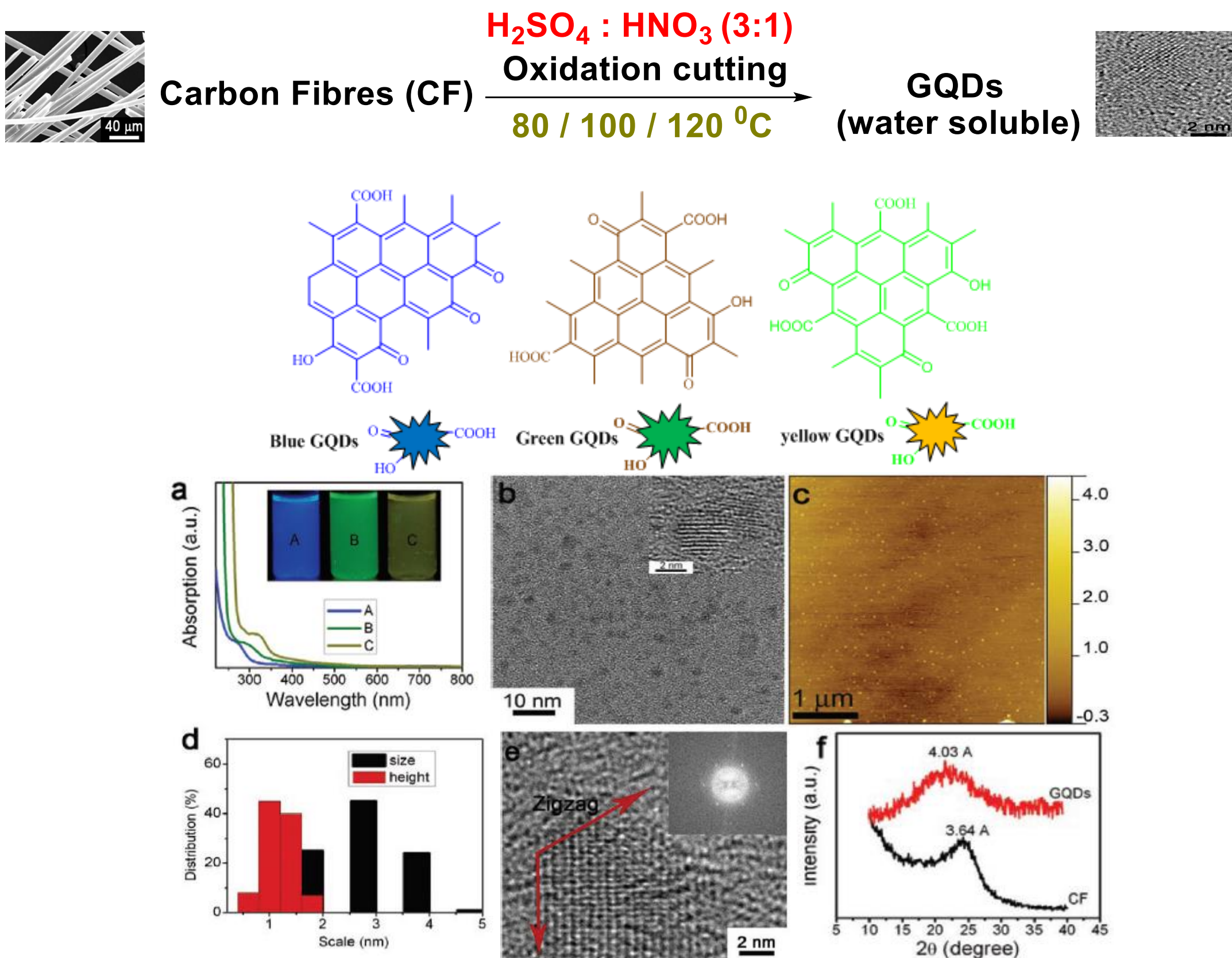
Carbon fibers have recently gained popularity for their variety of applications as a working electrode material. Due to their conductive nature, high specific surface area, and chemical inertness, they prove to be an ideal material for electrodeposition of a variety of materials for future in vivo or in situ biomedical applications. Here, we use cyclic voltammetry to simultaneously polymerize polypyrrole (PPy) and integrate graphene quantum dots (GQDs), while depositing onto a carbon fiber mesh (CF). Polypyrrole has been used in a variety of applications due to its conductive nature and GQDs have been used for their electronic properties as well. This nanocomposite will be further characterized using SEM, TEM, Raman, cyclic voltammetry, and electrochemical impedance spectroscopy to determine structural and functional capabilities.

## 1. Introduction

- GQDs fabricated by chemical exfoliation of carbon fibers show incredible electronic and optical properties. GQDs are in the range of 1-4nm and have significant potential for neural probe applications.<sup>1</sup>
- Polypyrrole is a conductive polymer that can be synthesized via electropolymerization; a 3-electrode configuration (monomer: pyrrole, solvent: water, and electrolyte: NaSO<sub>4</sub>) to produce thin films.<sup>4</sup>
- Doping material and amount can vary the conductivity of the polypyrrole due to its enhanced charge mobility along and between polymer chains.<sup>4</sup>
- Carbon fiber mesh is used as a working electrode due to its chemical inertness, outstanding mechanical and electrical properties, and high specific surface area for deposition. Further, due to their small diameter and biocompatibility, they have the potential to be used for in vivo and in situ applications.<sup>3</sup>
- Carbon fiber mesh was used in this application due to its flexibility.
- The proposed use of this nanocomposite material is for neural probe applications. Research has shown that increased neurite outgrowth and neuron differentiation has occurred with applied electrical stimulation.<sup>5</sup>

## 2. Fabrication of GQDs

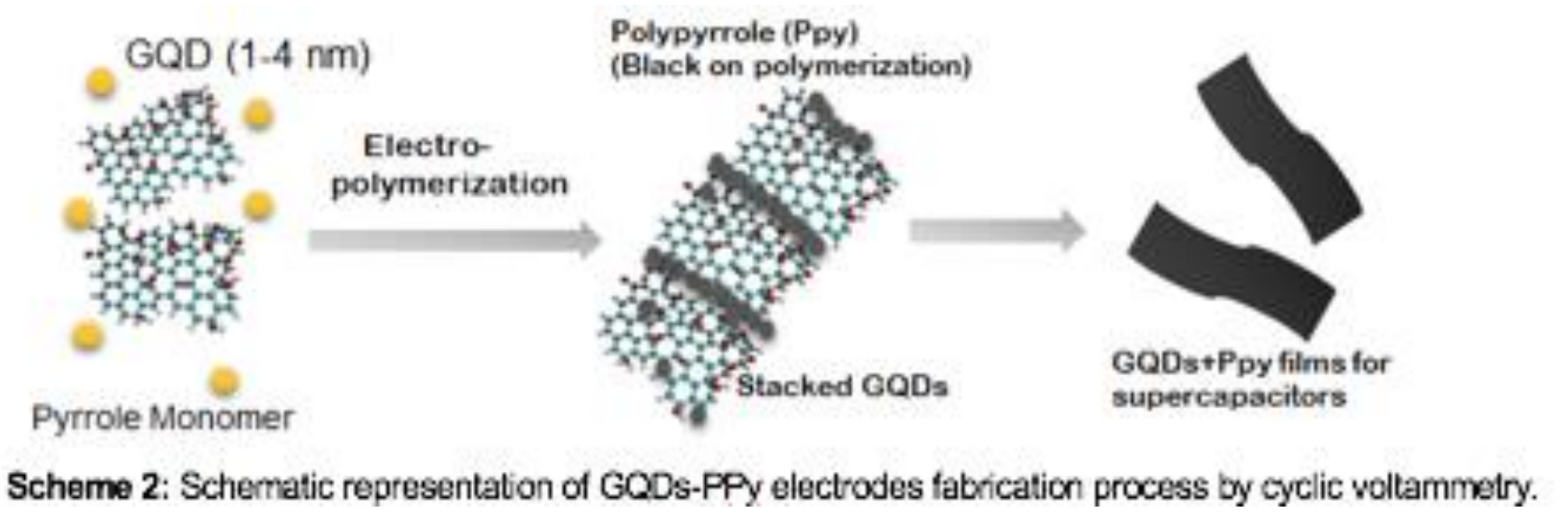
GQDs are fabricated by acid treatment and chemical exfoliation of carbon fibers<sup>1</sup>.



**Fig 1:** (a) UV-vis spectra of GQDs A, B, and C, corresponds to synthesized reaction temperature at 120, 100 and 80 °C respectively. (b) TEM images of GQDs (synthesized reaction temperature at 120 °C), inset of (b) is the HRTEM of GQDs. (c) AFM image of GQDs. (d) Size and height distribution of GQDs. (e) HRTEM image of the edge of GQD, inset is the 2D FFT of the edge.

## 3. Fabrication of Flexible Electrodes

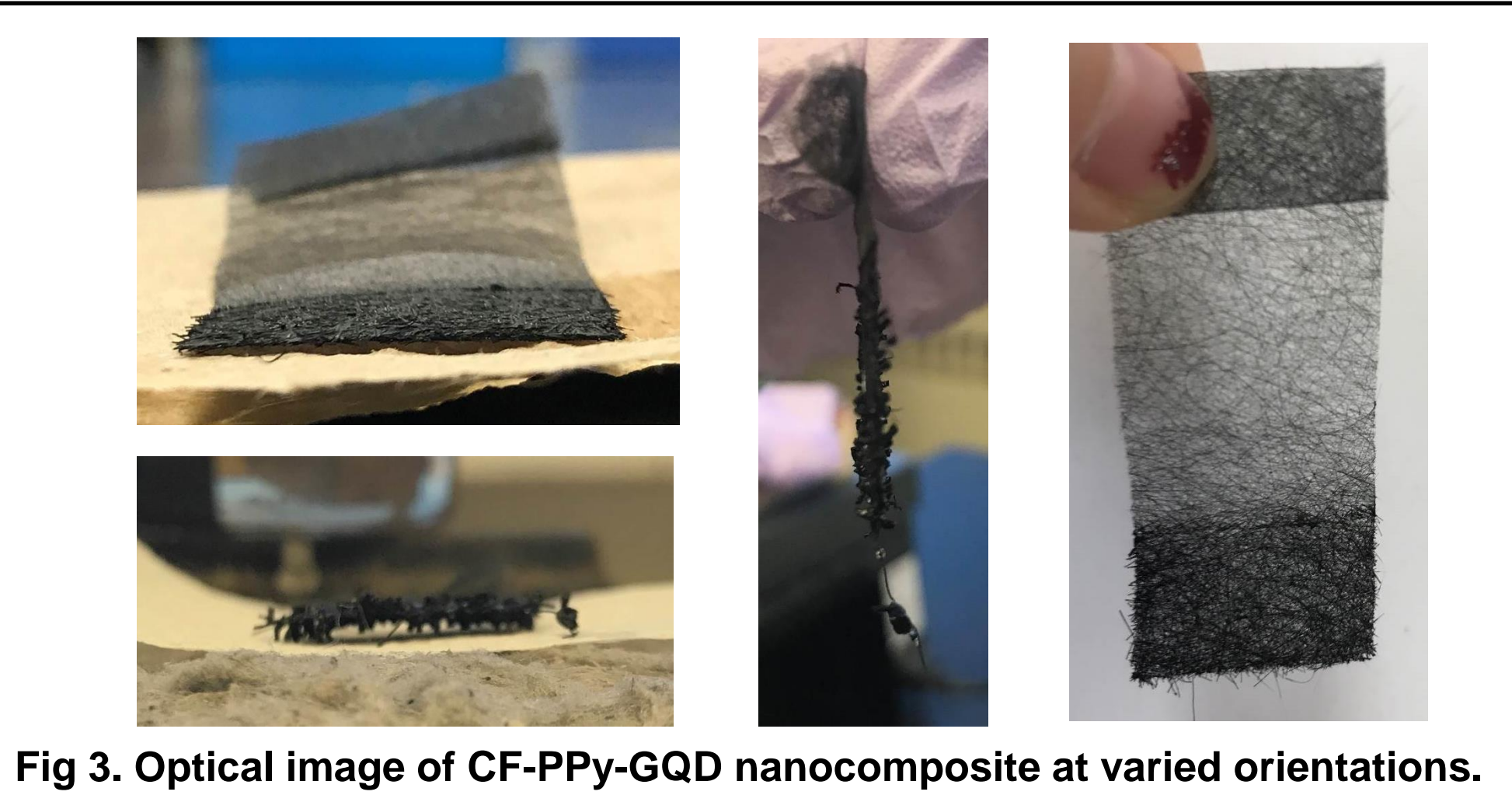
Here, we report the in-situ fabrication of a flexible carbon fiber mesh electrode via electrochemical polymerization and deposition (CV) of pyrrole, integrated with GQDs.



**Scheme 2:** Schematic representation of GQDs-PPy electrodes fabrication process by cyclic voltammetry.

Sample	Voltage (mV)	Scan Rate	Cycles
CF-PPy	800-900	10mV/s	250 500
		20mV/s	250 500
CF-PPy-GQD	800-900	10mV/s	250 500
		20mV/s	250 500

**Fig 2.** (a) Schematic of CV fabrication process of GQD-PPy nanocomposite. (b) CV parameters for nanocomposite samples.



## 4. Conclusions and Future Work

- Flexible nanocomposites were fabricated via electrodeposition, simultaneously incorporating a conductive polymer polypyrrole, nanomaterial graphene quantum dots, and a fibrous carbon fiber mesh.
- Due to high specific surface area, conductive nature, and unique nanomaterial properties, these materials have potential for a variety of biomedical and electronic applications.
- We will further focus on using these materials in neural probes applications.

## References

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